REMARKS

Favorable reconsideration of this application in view of the remarks to follow is respectfully requested.

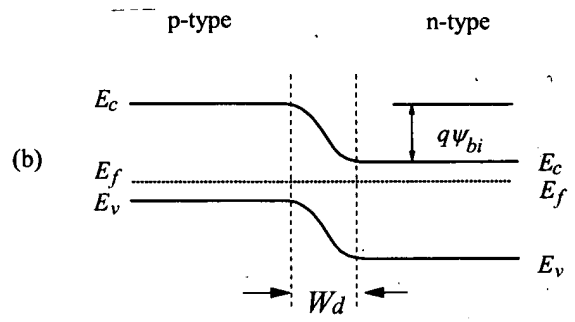
Before addressing the specific rejections raised in the Office Action dated November 20, 2002, applicant has amended Claim 1 to positively recite "*wherein said lightly doped region is directly underneath a base*". Referring to Page 8, line 25, applicant discloses, "FIG. 6 shows that there is no quasi-neutral collector region underneath the base region 14. *The collector region 18 directly underneath the base is fully depleted*". Applicant has also made minor amendments within the specification to be consistent with the submitted drawings.

In the present Office Action, Claims 1, 2, and 5 stand rejected under 35 U.S.C. §112, first paragraph, for allegedly not enabled by the specification. Claims 1 and 2 stand rejected under 35 U.S.C. §102(b) as allegedly anticipated by U.S. Patent No. 5,587,599 to Mahnkopf, et al. ("Mahnkopf, et al."). Claim 5 stands rejected under 35 U.S.C. §103(a) as allegedly obvious over Mahnkopf, et al. in view of U.S. Patent No. 5,506,427 to Imai ("Imai").

Referring to the rejection of Claims 1, 2 and 5 under 35 U.S.C. §112, first paragraph, it is the Examiner's position, referring to Page 2 of the present Office Action, that the electrical potentials and thickness of the collector region are allegedly critical or essential to the invention but not enabled by applicant's disclosure. Applicant respectfully disagrees and submits the following.

A patent specification must describe the claimed invention in sufficient detail that *one skilled in the art* can reasonably conclude that the inventor had possession of the claimed invention. *See, e.g., Vas Cath, Inc. v. Mahukar,* 953 F.2d at 1563, 19 USPQ2d at 1116. In transistor processing, it is well known within the ordinary skill of the art, that the thickness of the depletion layer (i.e., depleted collector region) is a function of the dopant concentration.

A n-p-n bipolar transistor comprises a p-n junction at the base/collector junction of the device. The energy band diagram of a p-n junction is as follows:



E_c = conduction band edges
E_v = valence band edges
E_f = Fermi levels
ψ_{bi} = built-in potential
W_d = depletion layer thickness

In the absence of any externally applied voltage across the p-n junction, the Fermi level E_f of the p-n junction is spatially constant. The fact that E_f is spatially constant across the entire p-n junction leads to the energy levels of the n-side of the junction being shifted down relative to the energy levels of the p-side, providing a built-in potential ψ_{bi} across a p-n junction. This built-in potential ψ_{bi} is dropped across a depletion layer of thickness W_d. It is called a depletion layer because there is an electric field in this layer caused by the potential drop across this layer. This electric field depletes any electrons or holes in this layer.

In the p-n junction at the base/collector junction of the present invention, one side is more heavily doped than the other. For example, in a typical base-collector diode, the p-type base region is doped more heavily than the n-type collector region. The relationship between the *depletion layer thickness* W_d and the built-in potential ψ_{bi} is given by:

$$W_d = \sqrt{\frac{2\varepsilon_{si}\psi_{bi}}{qN_d}}, \qquad (1)$$

where ε_{si} is the permittivity of the semiconductor, q denotes the absolute magnitude of the charge of an electron, and N_d is the doping concentration of the n-type region. *Equation (1) gives the relationship between the doping concentration and the depletion layer width.*

If there is a voltage V_{app} applied across the p-n junction, then instead of Equation (1), we have the relationship:

$$W_d = \sqrt{\frac{2\varepsilon_{si}(\psi_{bi} + V_{app})}{qN_d}} \quad . \qquad (2)$$

In this case, the *depletion layer thickness is not only a function of the collector doping concentration alone, but also a function of the voltage.*

One skilled in the art reading applicant's specification would comprehend that the *thickness of the depletion layer is a function of doping concentration.* For this reason, in order to practice the present invention, where full depletion of the collector layer of the transistor is achieved during device operation, all that is required is the collector doping concentration. Referring to Page 10, lines 5-8, applicant discloses, "a vertical bipolar transistor with a collector *doping concentration of* $2x10^{17}$ cm^{-3} and a *base-collector reverse bias of 3V*". One skilled in the art knowing the collector doping concentration and voltage supplied by applicant's disclosure would be able to reproduce and practice applicant's invention. Therefore, applicant has enabled the present invention and respectfully requests that the rejection under 35 U.S.C. §112, first paragraph, be withdrawn.

Turning now to the rejection of Claims 1 and 2, under 35 U.S.C. §102(b), it is axiomatic that anticipation under §102 requires the prior art reference to disclose every element to which it is applied. *In re King,* 801 F.2d 1324, 1326, 231 USPQ 36, 138 (Fed Cir, 1986). Thus, there must be no differences between the subject matter of the claim and the

disclosure of the prior art reference. Stated another way, the reference must contain within its four corners adequate direction to practice the invention as claimed. The corollary of the rule is equally applicable: absence from the applied reference of any claimed element negates anticipation. *Kloster Speedsteel AB v. Crucible Inc.*, 793 F.2d 1565, 1571, 230 USPQ 81, 84 (Fed. Cir. 1986).

Applicant submits that the claims of the present application are not anticipated by the disclosure of Mahnkopf, et al., since the applied reference does not disclose applicant's claimed structure. More specifically, Mahnkopf, et al. do not teach a bipolar transistor comprising a first single crystal semiconductor layer positioned over said insulating layer having a lightly doped region of a first type and at least one contiguous heavily doped region of said first type, said lightly doped region and said contiguous heavily doped region functioning as a collector, wherein the lightly doped region is directly underneath a base and is depleted of mobile charge carriers, as recited in amended Claim 1.

Applicant's claimed structure, as depicted in Fig. 6, includes a substrate 28, an insulating layer 26 over the substrate 28, a first single crystal semiconductor layer 18, 20, 22 positioned over the insulating layer 26 having a lightly doped region 18 of a first type and at least one contiguous heavily doped region 20, 22 of the first type, the lightly doped region 18 and the at least one contiguous heavily doped region 20, 22 functioning as a collector, *wherein said lightly doped region 18 is directly underneath a base 14*, a second patterned semiconductor layer 14 of a second type formed over said lightly doped region 18 of said first semiconductor layer to function as the base 14, and a third patterned semiconductor layer 12 of said first type position over the second semiconductor layer 14 to function as an-emitter 12, *the lightly doped region 18 of said first type having a dopant concentration to fully deplete of mobile charge carriers* through the first semiconductor layer 22, 20, 18 to the insulating layer 26. Applicant submits that the fully depleted region 18 of the collector is directly below the

base 14 of the bipolar transistor, therefore providing a fully-depleted-collector SOI vertical bipolar transistor which has a much smaller base-collector junction capacitance than conventional devices and does not require a heavily doped subcollector layer.

Mahnkopf, et al. do not anticipate applicant's claimed structure because the applied reference fails to disclose a bipolar transistor having a collector region comprising a *lightly doped region 18 directly underneath a base 14*, where the lightly doped region 18 fully depletes of mobile charge carriers, as recited in amended Claim 1. Mahnkopf, et al., referring to FIG. 5, disclose a bipolar transistor having a collector region where the lightest degree of doping produces a depleted region (n^-) in a lateral direction from the base (p) of the device. In the Mahnkopf transistor, the collector region (n) directly underneath the intrinsic base region (p) is not fully depleted. Collector region is quasi-neutral (n), being more heavily doped than the lightly doped region (n^-) that is laterally spaced from the base region (p) of the device. The quasi-neutral region (n) underlying the base region (p) results in a high series resistance collector. Therefore, since Mahnkopf, et al. fail to teach a *lightly doped region directly underneath a base, where the lightly doped region fully depletes of mobile charge carriers*; Mahnkopf, et al. fails to teach each and every aspect of the applicant's claimed invention.

Applicant further notes that the Mahnkopf, et al. transistor is far removed from the claimed structure, because the transistor disclosed in Mahnkopf, et al. functions similar to the prior art transistor described in FIG. 5 of applicant's specification. In the prior art transistor, depicted in FIG. 5 of applicant's specification, the electrons flow from the emitter region 3 through the base 4 into the collector 5. The collector 5 includes a the quasi-neutral region (n) having a very high resistance due in part to its relatively light doping concentration and relatively small thickness compared to the n+ type subcollector layer 7. The resulting collector series resistance is unacceptably large. The prior art transistor is depicted as follows:

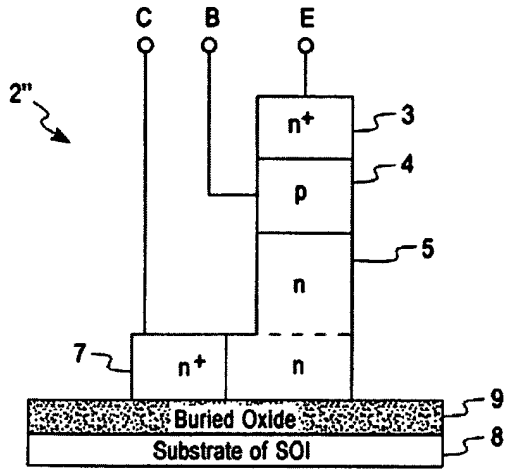
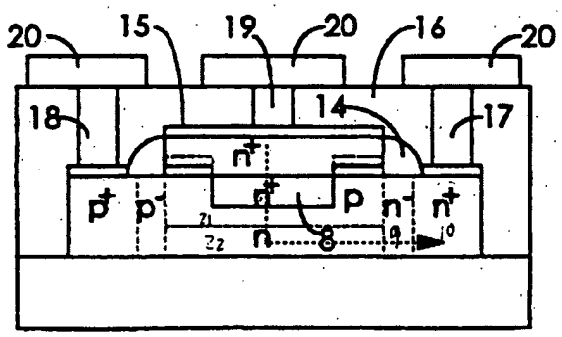


Fig. 5

The n-region 5 of the prior art transistor is equivalent to region (n) of the transistor depicted in FIG. 4 of Mahnkopf, et al.; both regions 5, (n) being quasi-neutral non-depleted regions having a high resistance. The transistor depicted by Mahnkopf, et al. is depicted as follows:



When the prior art transistor of Mahnkopf, et al. is turned on, electrons from the emitter region 8 flow vertically down across the intrinsic base layer (p) and are collected by the quasi-neutral region (n). This electron current is then carried from the quasi-neutral region (n) through a laterally spaced lightly doped region (n^-) to the collector contact region (n^+). The series resistance of the quasi-neutral region (n) is very high, making the transistor not suitable for most circuit applications.

Applicant has discovered that the high series resistance of the prior art devices, such as Mahnkopf, et al., is overcome by removing the quasi-neutral layer directly underlying the base region of the device with a fully depleted region. Applicant's produce a base depletion

region extending vertically through the entire n-type collector layer to the underlying insulator; therefore producing a low resistance collector region.

The forgoing remarks clearly demonstrate that the applied reference does not teach each and every aspect of the claimed invention as required by King and Kloster Speedsteel; et al., therefore, the claims of the present application are not anticipated by the disclosure of Mahnkopf, et al. Applicant respectfully submits that the instant §102 rejection has been obviated and withdrawal thereof is respectfully requested.

Now turning to the rejection under 35 U.S.C. §103(a), it is the Examiner's position that Claim 5 is allegedly obvious over Mahnkopf, et al. in view of Imai. "To establish a prima facie case of obviousness of a claimed invention all the claimed limitations must be taught or suggested by the prior art". *In re Wilson*, 424 F.2d 1382, 1385, 165 USPQ 44, 496 (CCPA 1970).

The primary reference, Mahnkopf, et al., is defective as a reference, under 35 U.S.C. §103(a), for the same reasons discussed above. To reiterate, Mahnkopf, et al. fail to teach or suggest a *lightly doped region 18 directly underneath a base 14*, where the lightly doped region fully depletes of mobile charge carriers through the first semiconducting layer to an isolating layer, as recited in amended Claim 1.

Imai fails to fulfill the deficiencies of the primary reference, since Imai also fails to teach or suggest a *lightly doped region 18 directly underneath a base 14*, where the lightly doped region fully depletes of mobile charge carriers through the first semiconducting layer to an isolating layer. Referring to FIG. 4, Imai discloses a bipolar transistor including a quasi-neutral collector 14 directly underlying a p-intrinsic base 36. The bipolar transistor disclosed in Imai, similar to the bipolar transistor of Mahnkopf, et al., includes a collector region that is not fully depleted of high mobility charge carriers and results in a collector region having a high series resistance. Therefore, Imai fails to teach or suggest a *lightly doped region 18*

directly underneath a base 14, where the lightly doped region 18 fully depletes of mobile charge carriers through the first semiconducting layer to an isolating layer, as recited in amended Claim 1.

The §103 rejection also fails because there is no motivation in the applied references that suggests modifying the structures disclosed therein to include applicant's claimed structure, which includes the features recited in amended Claim 1. The rejection is thus improper since the prior art does not suggest this drastic modification. The law requires that a prior art reference provide some teaching, suggestion, or motivation to make the modification obvious.

Here, there is no motivation provided in the disclosures of the applied prior art references, or otherwise of record, which would lead one skilled in the art to modify the structures of the applied references to include a *lightly doped region directly underneath*, where the lightly doped region fully depletes of mobile charge carriers through the first semiconducting layer to an isolating layer. "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Fritch, 972 F.2d, 1260,1266, 23 USPQ 1780,1783-84 (Fed. Cir. 1992).

There is no suggestion in the prior art of applicant's structure, therefore all the claims of the present application are not obvious from the combined prior art references cited in the present Office Action.

Based on the above amendments and remarks, the §103 rejection citing Mahnkopf, et al. in combination with Imai have been obviated; therefore reconsideration and withdrawal of the instant rejections are respectfully requested.

Thus, in view of the foregoing amendments and remarks, it is firmly believed that the present case is in condition for allowance, which action is earnestly solicited.

Respectfully submitted,

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